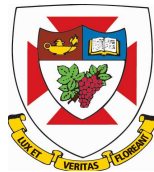


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Regional versus Multilateral Trade Liberalization, Environmental Taxation and Welfare

Soham Baksi *

Abstract

We consider strategic trade among identical countries and compare the impacts of multilateral versus regional tariff reduction on equilibrium pollution tax and social welfare. While both forms of trade liberalization increase production and consumption in the tariff-reducing countries, regional trade liberalization also reduces production in a non-participating country and may decrease its consumption. When pollution is local, regional and multilateral trade liberalization have similar impacts in the tariff-reducing countries. In contrast, when pollution is perfectly transboundary, regional (multilateral) trade liberalization (i) weakens (may strengthen) environmental protection in the tariff-reducing countries, and (ii) in the neighbourhood of free trade, may increase (decreases) welfare of the tariff-reducing countries.

JEL classifications: Q58; F18; H23

Keywords: Environmental taxation; Trade liberalization; Regional trade agreements

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1 Introduction

Environmentalists have long worried that expanded international trade will detrimentally and sometimes irreparably affect the ecosystem. One concern is that competitive pressures unleashed by trade will force governments to weaken their environmental policies, and may even lead to the emergence of pollution havens. The transboundary nature of many pollutants will also make it unlikely that governments, acting non-cooperatively, will pursue globally efficient environmental policies. A growing body of literature in economics has examined these concerns (e.g. Krutilla, 1991; Ulph, 1996; Antweiler, et al., 2001; Greenstone, 2002; McAusland, 2008; Managi, et al. 2009).¹ In general, economists have pointed out that the relation between international trade and the environment is a multifaceted one and the impacts can go either way depending on the specific context. For example, while the “scale effect” associated with trade liberalization tends to increase pollution, the “technique effect” tends to decrease it. Moreover, the “composition effect” of trade liberalization can increase or decrease pollution in a country depending on its comparative advantage (Copeland and Taylor, 2003).

In the presence of imperfect competition, countries trading with each other have an incentive to strategically distort their environmental policy in order to increase their welfare in the non-cooperative equilibrium (Barrett, 1994; Kennedy, 1994). When imperfectly competitive firms compete in terms of quantities, reducing domestic firms’ environmental costs makes them more competitive internationally, enabling a country to capture additional rents. This tends to inefficiently weaken environmental policy in these countries. At the same time, a desire to shift polluting production from itself to its trading partners can lead each country to make its environmental policy inefficiently stringent. For the case of symmetric countries and transboundary pollution, Kennedy (1994) concludes that the net impact under *free trade* is a lowering of the pollution tax below its efficient level.

While Kennedy identifies how the equilibrium pollution tax may be distorted under free trade, Burguet and Sempere (2003) examine how *trade liberalization* (in the form of bilateral tariff reduction) affects environmental policy and welfare by changing the various distortionary forces. Using a model of bilateral trade with imperfect competition

¹Most of the literature on trade and environment has modeled pollution as affecting the utility function rather than the production function. A few papers that analyze the latter scenario include Copeland and Taylor (1999), and Benarroch and Thille (2001).

and local pollution, the authors show that trade liberalization can make environmental policy more or less stringent, depending on factors such as the convexity of the damage function and the emission intensity of output. On the one hand, by increasing output, trade liberalization increases marginal social cost of output, which tends to tighten environmental policy. On the other hand, lower tariffs imply lower import revenue, which tends to make environmental policy more lax. The net impact on equilibrium environmental policy depends on the relative strength of these counteracting forces. Further, Burguet and Sempere find that when the environmental policy instrument is a pollution tax, marginal social cost is always less than price. Consequently, by increasing output, a bilateral tariff reduction always increases welfare of each country.²

One limitation of the literature on trade liberalization and strategic environmental policy is that it usually considers a two-country framework and examines the symmetric case of trade liberalization by both countries. This is akin to an examination of the impact of *multilateral* trade liberalization (when there are more than two countries) on the environment. However, much trade liberalization worldwide has involved *regional* trade agreements, where a sub-group of trading countries decides to gradually reduce tariff on each others imports.³ In fact, while multilateral trade negotiations under the auspices of the WTO have fumbled in recent years, regional trade agreements (RTAs) have proliferated.⁴ When tariff reduction takes such a regional form, the impact on strategic environmental policy and welfare in the participating and non-participating countries is likely to be different from those under multilateral tariff reduction. The current paper examines this under-explored issue of the environmental and welfare impacts of RTAs and compares these impacts with those under multilateral trade liberalization.

While there has been a recent move towards incorporating environmental issues in international trade agreements, the coordination of trade and environmental policies

²In their Proposition (p. 31), Burguet and Sempere (2003) note, “If the environmental instrument is a tax (either on output, input, or emissions), a bilateral reduction in tariffs increases welfare.”

³For example, under NAFTA, the participating countries (Canada, Mexico and the US) agreed to reduce their tariffs in equal annual stages over a specified number of years.

⁴As the WTO notes, “The surge in RTAs has continued unabated since the early 1990s. As of 15 May 2011, some 489 RTAs, counting goods and services notifications separately, have been notified to the GATT/WTO. At that same date, 297 agreements were in force... The overall number of RTAs in force has been increasingly steadily, a trend likely to be strengthened by the many RTAs currently under negotiations.” (see http://www.wto.org/english/tratop_e/region_e/region_e.htm). For detailed information on all the RTAs currently in force, see <http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx>

across countries remains largely absent (OECD, 2007).⁵ On the other hand, as international trade agreements have progressively left countries with less flexibility to pursue independent tariff policies, this has motivated some countries to use environmental (and other domestic) policy instruments in order to achieve trade policy objectives (Ederington and Minier, 2003).

When environmental policy is strategically chosen by countries, our analysis indicates that the impact of freer trade on environmental protection and welfare depends on the nature of the trade liberalization process. The differences in outcomes for multilateral vs. regional trade liberalization exist even when the countries are identical. We find that, while multilateral trade liberalization increases production and consumption in the tariff-reducing countries, regional trade liberalization reduces production in the non-participating country and may decrease its consumption as well. The changes in consumption and production have corresponding impacts on the rent capture and pollution shifting effects in these countries. Further, the tariff effect of trade liberalization tends to reduce equilibrium pollution tax in tariff-reducing countries in the multilateral case, but tends to increase the non-participating country's pollution tax in the case of regional trade liberalization.

The paper shows that multilateral and regional trade liberalization affects pollution tax and welfare in tariff-reducing countries in similar ways when pollution damage is localized, but in dissimilar ways when pollution is largely transboundary. For global pollutants such as greenhouse gases, we find that regional (multilateral) trade liberalization (i) weakens (may strengthen) environmental protection in the tariff-reducing countries, and (ii) in the neighbourhood of free trade, may increase (decreases) welfare of the tariff-reducing countries. The asymmetry inherent in regional trade liberalization makes it more likely than multilateral trade liberalization to weaken environmental protection in the tariff-reducing (but otherwise identical) countries. Furthermore, regional trade liberalization is found to affect pollution tax and welfare in the participating and non-participating countries in dissimilar ways. For instance when pollutants have very harmful but localized impacts, regional trade liberalization strengthens environmental

⁵The OECD (2007) report notes, "In spite of these developments, the number of RTAs including significant environmental provisions remains small, and there is still much scepticism, especially among developing countries, toward dealing with environment in the context of trade agreements... Trade and environment debates have traditionally seen developing country negotiators cautious about incorporating environmental considerations into multilateral trade agreements. Similar concerns apply to the integration of environmental considerations into RTAs. Among the concerns are that environmental considerations will result in trade barriers or that their implementation will constitute an excessive burden in terms of financial and human resources." (<http://www.oecd.org/dataoecd/56/55/38664937.pdf>)

protection in participating countries but weakens such protection in non-participating countries.

We proceed as follows. Section 2 presents the model, where three countries with oligopolistic markets engage in international trade in a polluting good, and derives its equilibrium. In section 3, we analyze the benchmark scenario where the countries undertake multilateral tariff reduction. Section 4 then takes up the case of regional trade liberalization where two countries (the “participating countries”) engage in bilateral tariff reduction while the third country (the “non-participating country”) stays out of this process. The results from multilateral and regional trade liberalization are compared in section 5, while the last section concludes.

2 The model

Consider three identical countries, 1, 2 and 3, with segmented markets. There are n firms in each country, with $n \geq 1$. All firms produce a homogeneous good and face a constant marginal cost of production, given by c . Each firm in country 1 sells x_i units of the good in country i , where $i = 1, 2, 3$. Each firm in country 2 sells y_i units in country i . Each firm in country 3 sells z_i units of the good in country i .

In each market, firms compete in quantities, i.e. *à la* Cournot. Inverse demand in each country is identical and given by

$$p(Q_i) = p(0) - Q_i$$

where $p(0) - c \equiv a > 0$, and Q_i is total quantity sold in country i . Country 1 (respectively, country 2) charges a tariff of ϕ per unit of import from country 2 (respectively, country 1). Countries 1 and 2, each charges a tariff of Φ per unit of import from country 3. Country 3 charges a tariff of Φ per unit of import from countries 1 and 2 (see Figure 1). The tariffs are given exogenously in our model. Initially, i.e. pre-trade liberalization, the tariff rates are the same (i.e. $\Phi = \phi$) in identical countries.

Trade liberalization takes the form of a reduction in the relevant tariff rate. Two alternative forms of trade liberalization are considered. We define “multilateral trade liberalization” as an equal multilateral reduction in the tariff rates ϕ and Φ by all three countries, and analyze this benchmark scenario in Section 3. The next section considers “regional trade liberalization”, defined as an equal bilateral reduction in the tariff rate ϕ by countries 1 and 2 only (with Φ remaining unchanged). This reflects the situation

subsequent to the signing of a regional trade agreement amongst a sub-group of the trading partners (countries 1 and 2) while others remain outside the agreement (country 3, in our case). Unlike multilateral trade liberalization, regional trade liberalization introduces an asymmetry among the three ex-ante identical countries.

A by-product of production in this industry is pollution. With appropriate definition of units, it is assumed that, for every unit of output produced, the firms emit one unit of pollution.⁶ The pollution is transboundary where $\gamma \in [0, \frac{1}{3}]$ fraction of pollution generated in one country affects each of the other two countries. The social cost of pollution is increasing and convex in the level of emissions affecting a country. The pollution damage function in country i , given by D_i , is as follows:

$$D_1 = \frac{1}{2}\beta [(1 - 2\gamma)X + \gamma Y + \gamma Z]^2 \quad (1)$$

$$D_2 = \frac{1}{2}\beta [\gamma X + (1 - 2\gamma)Y + \gamma Z]^2 \quad (2)$$

$$D_3 = \frac{1}{2}\beta [\gamma X + \gamma Y + (1 - 2\gamma)Z]^2 \quad (3)$$

where $\beta \geq 0$ is the pollution damage parameter, and the total production undertaken in countries 1, 2 and 3 are respectively $X \equiv n \sum_{i=1}^3 x_i$, $Y \equiv n \sum_{i=1}^3 y_i$ and $Z \equiv n \sum_{i=1}^3 z_i$. Different values of the transboundary pollution or spillover parameter, γ , allow us to consider a continuum of cases ranging from strictly local pollution ($\gamma = 0$) to perfectly transboundary pollution ($\gamma = \frac{1}{3}$).⁷ The environmental policy in country i is a tax imposed on domestic firms at the rate t_i per unit of emission. Given our assumption of constant emission-output ratio, a tax per unit of emission is equivalent to a tax per unit of the polluting good.

The sequence of moves is as follows. In the first stage, (an environmental authority in) each country chooses its pollution tax to maximize the country's own welfare, taking the other countries' pollution taxes (and the tariffs, ϕ and Φ) as given. In the second stage, each firm takes the policies set by the countries and the output decisions of the

⁶Thus we are assuming a constant emission intensity of output. Emissions can be reduced through a reduction in output, with foregone profit being the abatement cost for a firm. Allowing firms to separately choose their level of abatement does not change our results qualitatively.

⁷When $\gamma = \frac{1}{3}$, pollution generated in each country affects all three countries equally. We are ignoring situations where $\gamma \in (\frac{1}{3}, \frac{1}{2}]$, i.e. where pollution generated in each country affects that country less than it affects the other countries. In a setting where pollution flows from an upstream to a downstream country, γ could exceed $\frac{1}{3}$ in the upstream (but not the downstream) country. Since we are assuming γ is identical across the three countries, we restrict its value to the $[0, \frac{1}{3}]$ interval.

$(3n - 1)$ other firms as given, and chooses its own output. To obtain the subgame perfect Nash equilibrium, the model is solved using backward induction.

2.1 Second stage: Output decision of firms

Total quantity sold in country i is given by $Q_i = n(x_i + y_i + z_i)$. The profit maximization problems of each firm in countries 1, 2 and 3 are respectively given by (4), (5) and (6):

$$\max_{x_1, x_2, x_3} \sum_{i=1}^3 x_i (a - Q_i) - t_1 \sum_{i=1}^3 x_i - \phi x_2 - \Phi x_3 \quad (4)$$

$$\max_{y_1, y_2, y_3} \sum_{i=1}^3 y_i (a - Q_i) - t_2 \sum_{i=1}^3 y_i - \phi y_1 - \Phi y_3 \quad (5)$$

$$\max_{z_1, z_2, z_3} \sum_{i=1}^3 z_i (a - Q_i) - t_3 \sum_{i=1}^3 z_i - \Phi z_1 - \Phi z_2 \quad (6)$$

The Cournot-Nash equilibrium quantities for the three markets are computed. The quantities sold in country 1 and country 2 are:

$$\begin{aligned} x_1 &= \frac{1}{3n+1} [a + n(\phi + \Phi) - t_1(1 + 2n) + n(t_2 + t_3)] \\ y_1 &= \frac{1}{3n+1} [a + n\Phi - (1 + 2n)(t_2 + \phi) + n(t_1 + t_3)] \\ z_1 &= z_2 = \frac{1}{3n+1} [a + n\phi - (1 + 2n)(t_3 + \Phi) + n(t_1 + t_2)] \\ x_2 &= \frac{1}{3n+1} [a + n\Phi - (1 + 2n)(t_1 + \phi) + n(t_2 + t_3)] \\ y_2 &= \frac{1}{3n+1} [a + n(\phi + \Phi) - t_2(1 + 2n) + n(t_1 + t_3)] \end{aligned} \quad (7)$$

The quantities sold in country 3 are given by:

$$\begin{aligned} x_3 &= \frac{1}{3n+1} [a - \Phi(1 + n) - t_1(1 + 2n) + n(t_2 + t_3)] \\ y_3 &= \frac{1}{3n+1} [a - \Phi(1 + n) + n(t_1 + t_3) - t_2(1 + 2n)] \\ z_3 &= \frac{1}{3n+1} [a + 2n\Phi - t_3(1 + 2n) + n(t_1 + t_2)] \end{aligned} \quad (8)$$

We assume that parameter values are such that each of the above quantities is positive. Country 1's total production is $X = n(x_1 + x_2 + x_3)$, total consumption is $Q_1 = n(x_1 + y_1 + z_1)$, and net import is $n(y_1 + z_1 - x_2 - x_3) = n\left(2t_1 - t_2 - t_3 + \frac{n(\phi - \Phi)}{3n+1}\right)$. Similarly, country 3's net import is $n(x_3 + y_3 - z_1 - z_2) = n\left(2t_3 - t_1 - t_2 + \frac{2n(\Phi - \phi)}{3n+1}\right)$.

2.2 First stage: Equilibrium environmental policy

In the first stage of the game, each country chooses the pollution tax rate that maximizes its own welfare, taking as given the tariff levels and the other countries' pollution taxes. Social welfare is defined to be the sum of consumer surplus, producer surplus, tariff revenue and pollution tax revenue less pollution damage. Welfare in country i , W_i , is thus given by

$$W_i(t_1, t_2, t_3) \equiv CS_i + PS_i + TR_i + ER_i - D_i, \quad i = 1, 2, 3 \quad (9)$$

In country 1, for example, we have that consumer surplus $CS_1 = \frac{1}{2}(n(x_1 + y_1 + z_1))^2$, producer surplus $PS_1 = n(x_1^2 + x_2^2 + x_3^2)$, tariff revenue $TR_1 = n(\phi y_1 + \Phi z_1)$, pollution tax revenue $ER_1 = nt_1(x_1 + x_2 + x_3)$, and pollution damage D_1 is as given by (1).

The non-cooperative Nash equilibrium pollution tax in each country is computed by simultaneously solving the three first order conditions: $\frac{\partial W_i(t_1, t_2, t_3)}{\partial t_i} = 0$ for $i = 1, 2, 3$. We denote these equilibrium taxes, which are a function of the tariff rates, as $\bar{t}_1(\phi, \Phi) = \bar{t}_2(\phi, \Phi)$ and $\bar{t}_3(\phi, \Phi)$. The second order condition for welfare maximization is satisfied since we have the following:

$$\frac{\partial^2 W_1}{\partial t_1^2} = \frac{\partial^2 W_2}{\partial t_2^2} = \frac{\partial^2 W_3}{\partial t_3^2} = -n^2 \frac{12n + 5 + 9\beta(\gamma(6n + 2) - 2n - 1)^2}{(3n + 1)^2} < 0.$$

3 Multilateral trade liberalization

We begin by analyzing the benchmark case of multilateral trade liberalization, where all three countries start from the same initial tariff rate (i.e. $\Phi = \phi$) and undertake an equal marginal reduction in that rate.⁸ We analyze the impact of such multilateral tariff reduction on the equilibrium pollution tax and welfare in each country. Since

⁸The benchmark case is similar to Bakshi and Ray Chaudhuri (2009), who examine the effects of multilateral trade liberalization using a two-country model and an alternative specification of the pollution spillover process.

tariff rates are equal across the countries both before and after trade liberalization, the equilibrium pollution tax rate and welfare levels are also identical in the three countries under this symmetric scenario.

By substituting $\Phi = \phi$ in $\bar{t}_i(\phi, \Phi)$, the equilibrium pollution tax rate in each country is derived as $\bar{t}_i^m = \bar{t}^m(\phi)$ for $i = 1, 2, 3$, where

$$\bar{t}^m(\phi) \equiv \frac{3a(2n+1) - 3\beta n(3a-2\phi)(1-2\gamma+2n(1-3\gamma)) - 2\phi(3n+3n^2+1)}{9n(2\beta\gamma(3n+1) - (1+\beta)(2n+1))} \quad (10)$$

and the superscript ‘ m ’ is used to denote this multilateral trade liberalization scenario.

The various sources of distortions that tend to make the equilibrium tax globally inefficient are as follows. First, there is the “transboundary externality effect” that tends to lower \bar{t}^m from its globally efficient level, as each country ignores the impact of pollution generated within its own borders on welfare in the other countries. Second, there is the “rent capture effect” that also tends to lower the equilibrium pollution tax. Since the imperfectly competitive firms enjoy rents, each government has a strategic incentive to provide a competitive advantage to its domestic firms so that they are able to capture more foreign rent. Third, there is a “pollution shifting effect” (or a not-in-my-backyard effect) that tends to increase \bar{t}^m , as each country tries to drive polluting production from itself to the other countries.

The transboundary externality effect and the pollution shifting effect depend on the extent to which pollution crosses jurisdictions. As γ increases from 0 to $\frac{1}{3}$, the former effect becomes stronger while the latter effect becomes weaker. Note that when the good is clean (i.e. $\beta = 0$), both these effects are non-existent. Moreover, the rent capture effect disappears when the market becomes competitive (i.e. as $n \rightarrow \infty$). The equilibrium pollution tax (10) in such a case becomes

$$\lim_{n \rightarrow \infty} \bar{t}^m(\phi) |_{\beta=0} = \frac{1}{3}\phi. \quad (11)$$

As long as there is positive tariff (i.e. $\Phi = \phi > 0$), each country enjoys tariff revenue on imports and has to pay for exports. This gives them an incentive to substitute foreign production for domestic production, and consequently to tax domestic firms (the “tariff effect” on the equilibrium tax). It is only when there is free trade (i.e. $\Phi = \phi = 0$) as well, that the equilibrium pollution tax rate in each country, (11), becomes zero.

In the symmetric equilibrium, substituting $t_i = \bar{t}^m(\phi)$ in (7) and (8), we have total

output produced equal to total output consumed in each country, so that its net import is zero.⁹ The total output, produced or consumed, in each country is

$$Q_i(\phi) = \frac{3a(1+2n) - 2\phi(1+3n)}{3((1+2n) + \beta(1-2\gamma) + 2n\beta(1-3\gamma))}$$

Multilateral tariff reduction increases output in each country as $\frac{\partial Q_i}{\partial \phi} < 0$. Moreover, the prohibitive tariff rate, at which imports become zero, is given by¹⁰

$$\phi_{\max}^m \equiv \frac{3a(2n+1)}{3\beta n(1-2\gamma+2n(1-3\gamma)) + 6n^2 + 9n + 2}$$

The impact of multilateral trade liberalization on the above-mentioned effects, and their trade-off, determines how the equilibrium pollution tax changes as a result. From (10), we have

$$\frac{\partial \bar{t}^m(\phi)}{\partial \phi} = \frac{2}{9n} \frac{1+3n+3n^2 - 3n\beta(1-2\gamma+2n(1-3\gamma))}{2n+1+\beta(1-2\gamma)+2n\beta(1-3\gamma)} \quad (12)$$

From (12), Proposition 1 follows.

Proposition 1: *Multilateral tariff reduction leads to an increase in the equilibrium pollution tax in each country (i.e. $\frac{\partial \bar{t}_i^m}{\partial \phi} \leq 0$) if and only if the pollution is sufficiently harmful (i.e. $\beta \geq \frac{1+3n+3n^2}{3n(1-2\gamma+2n(1-3\gamma))} \equiv \beta_A^m$).*

Note that the threshold value of the pollution damage parameter, β_A^m , itself depends on the extent to which pollution is transboundary. As output increases and price falls with trade liberalization, this increases pollution damage and decreases rents. Consequently, a country's incentive to raise tax to drive out polluting production increases, and its incentive to lower tax to capture additional rents decreases. These exert an *upward pressure* on the equilibrium pollution tax. However, a lower tariff also reduces tariff revenues from imports. This reduces the country's incentive to substitute foreign production for domestic production by increasing the tax. As a result, equilibrium pollution tax tends to *decrease*. The net impact on the tax depends on the relative strength of the two counteracting forces.

Substitution of the equilibrium tax $t_i = \bar{t}^m(\phi)$ into (9) gives the equilibrium welfare in each country, $W_i = \bar{W}^m(\phi)$. The effect of multilateral trade liberalization on welfare

⁹This is similar to reciprocal dumping (Brander and Krugman, 1983).

¹⁰That is, $x_2 = x_3 = y_1 = y_3 = z_1 = z_2 \geq 0$ if and only if $\phi \leq \phi_{\max}^m$.

is then given by

$$\frac{\partial \bar{W}^m(\phi)}{\partial \phi} = \frac{4(3a\beta\gamma - \beta\phi - \phi)(3n+1)^2}{9(\beta(2n(1-3\gamma) + 1 - 2\gamma) + 2n+1)^2} \quad (13)$$

From (13), Proposition 2 follows.

Proposition 2: *In the presence of transboundary pollution, multilateral tariff reduction leads to an increase in the welfare of each country (i.e. $\frac{\partial \bar{W}^m(\phi)}{\partial \phi} \leq 0$) if and only if the initial tariff rate ϕ is sufficiently large (specifically $\phi \geq \frac{3a\beta\gamma}{1+\beta} \equiv \phi_A^m$).*

The above threshold tariff ϕ_A^m is less than the prohibitive tariff ϕ_{\max}^m whenever $n\beta\gamma < \frac{1}{3}$.

Whether tariff reduction, by increasing output, increases welfare of a country or not depends on whether initially price exceeds marginal social cost of output in that country. When pollution is cross-boundary, Proposition 2 indicates that welfare is non-monotonic and concave in ϕ . It is only when tariff is sufficiently high ($\phi > \phi_A^m$), and the associated output sufficiently low, that price exceeds marginal social cost. An increase in output due to multilateral tariff reduction then increases welfare. The opposite result holds when $\phi < \phi_A^m$. Thus, in the neighbourhood of free trade (when $\phi \rightarrow 0$), multilateral tariff reduction decreases welfare in each country as long as $\beta\gamma > 0$.¹¹

An implication of the non-monotonicity of $\bar{W}^m(\phi)$ is that the direction of change in welfare of a country due to marginal multilateral reductions in tariff may not be the same as that due to a discrete jump in tariff (to free trade, for example). Note that $\bar{W}^m(\phi)$ is non-monotonic and concave in ϕ even when markets are competitive and rents tend to zero.¹² Existence of the rent capture effect is, therefore, not necessary for Proposition 2 to hold. In contrast, if the good was clean and the transboundary externality and pollution shifting effects were absent, multilateral trade liberalization would always increase welfare.¹³ Furthermore, the threshold value of tariff, ϕ_A^m , is an increasing function of the transboundary pollution parameter γ . In fact when pollution is purely local (as in Burguet and Sempere, 2003), trade liberalization always improves welfare as (13) implies $\frac{\partial \bar{W}^m(\phi)}{\partial \phi}|_{\gamma=0} = -\frac{4\phi(3n+1)^2}{9(\beta+1)(2n+1)^2} < 0$.

¹¹We have, $\lim_{\phi \rightarrow 0} \left(\frac{\partial \bar{W}^m(\phi)}{\partial \phi} \right) = \frac{4a\beta\gamma(3n+1)^2}{3(\beta(2n(1-3\gamma)+1-2\gamma)+2n+1)^2} > 0$

¹²As $\lim_{n \rightarrow \infty} \left(\frac{\partial \bar{W}^m(\phi)}{\partial \phi} \right) = \frac{3a\beta\gamma - \beta\phi - \phi}{(1+\beta-3\beta\gamma)^2}$.

¹³Again, $\frac{\partial \bar{W}^m(\phi)}{\partial \phi}|_{\beta=0} = -\frac{4\phi(3n+1)^2}{9(2n+1)^2} < 0$

4 Regional trade liberalization

We now move from multilateral trade liberalization, where all countries trading with each other reduce their tariff rate, to regional trade liberalization where only a subset of the trading countries reduce their tariff rate. Specifically, we analyze the impact of an equal bilateral reduction in the tariff rate ϕ by countries 1 and 2, with Φ remaining unchanged. This could, for instance, happen if countries 1 and 2 sign a trade agreement and decide to gradually move towards a regional free trade area, which does not include country 3. Now we have an asymmetric case where the impact of regional trade liberalization in the participating countries (countries 1 and 2) will differ from that in the non-participating country (country 3).

The Nash equilibrium pollution taxes in each country, $\bar{t}_1(\phi, \Phi) = \bar{t}_2(\phi, \Phi)$ and $\bar{t}_3(\phi, \Phi)$, are still subject to similar effects as mentioned in Section 3. Although qualitatively similar, the magnitudes of these effects differ across the countries when $\Phi \neq \phi$. For instance, when $\beta = 0$ and the transboundary externality and pollution shifting effects are absent, the equilibrium pollution taxes are given by

$$\bar{t}_i(\phi, \Phi) |_{\beta=0} = \frac{\Phi(1 - 6n^2) + \phi B - A}{27n(3n+1)(2n+1)}, \quad i = 1, 2$$

$$\bar{t}_3(\phi, \Phi) |_{\beta=0} = \frac{2\Phi B - 2\phi(18n + 42n^2 + 27n^3 + 2) - A}{27n(3n+1)(2n+1)},$$

where $A \equiv 9a(2n+1)(3n+1)$ and $B \equiv 36n + 78n^2 + 54n^3 + 5$. Moreover, in the limiting case when the number of firms $n \rightarrow \infty$ and the rent capture effect is eliminated as well, the equilibrium pollution taxes due to the tariff effect are given by

$$\lim_{n \rightarrow \infty} \bar{t}_i(\phi, \Phi) |_{\beta=0} = \frac{1}{3}\phi, \quad i = 1, 2 \tag{14}$$

$$\lim_{n \rightarrow \infty} \bar{t}_3(\phi, \Phi) |_{\beta=0} = \frac{1}{3}(2\Phi - \phi) \tag{15}$$

Lemma 1: *A bilateral reduction in ϕ tends to reduce equilibrium pollution tax in the participating countries, and increase that in the non-participating country, through the tariff effect.*

The above lemma follows from (14) and (15). Note that the tariff effect on the equilibrium pollution tax in the participating countries is independent of Φ , while that in the non-participating country depends on both ϕ and Φ . In particular, the tariff

effect encourages the non-participating country to subsidize production when its own tariff Φ is (close to) zero, as $\lim_{n \rightarrow \infty} (\bar{t}_3(\phi, \Phi) |_{\beta=0, \Phi=0}) = -\frac{1}{3}\phi < 0$.¹⁴

Substituting the Nash equilibrium taxes, $\bar{t}_1(\phi, \Phi) = \bar{t}_2(\phi, \Phi)$ and $\bar{t}_3(\phi, \Phi)$, into (7) and (8) gives the equilibrium quantities $\bar{x}_i(\phi, \Phi)$, $\bar{y}_i(\phi, \Phi)$ and $\bar{z}_i(\phi, \Phi)$. Net imports (i.e. consumption minus production) of country 1 and country 3 are respectively given by

$$Q_1 - X = n(x_1 + y_1 + z_1) - n(x_1 + x_2 + x_3) = \frac{1}{3} \frac{(\phi - \Phi)((3n+1)^2 - 3n\beta C)}{(3n+1)(1+3\beta C)}$$

$$Q_3 - Z = n(x_3 + y_3 + z_3) - n(z_1 + z_2 + z_3) = \frac{2}{3} \frac{(\Phi - \phi)((3n+1)^2 - 3n\beta C)}{(3n+1)(1+3\beta C)}$$

where $C \equiv (1 - 3\gamma)(2n(1 - 3\gamma) + 1 - 2\gamma) \geq 0$. Net imports are negative (positive) in the participating countries (non-participating country) when $\phi < \Phi$ and β is sufficiently small. Moreover, we have

$$\frac{\partial X}{\partial \phi} = \frac{\partial Y}{\partial \phi} < 0; \quad \frac{\partial Q_1}{\partial \phi} = \frac{\partial Q_2}{\partial \phi} < 0; \quad \frac{\partial Z}{\partial \phi} > 0; \quad \frac{\partial (X + Y + Z)}{\partial \phi} < 0 \quad (16)$$

$$\frac{\partial Q_3}{\partial \phi} = \frac{2}{9} \frac{3n\beta(1 - 2\gamma) + 6n^2\beta(1 - 3\gamma) - 1 - 3n - 3n^2}{n(3n+1)(1 + 2n + \beta(2n(1 - 3\gamma) + 1 - 2\gamma))} \quad (17)$$

From (16) and (17), Lemma 2 follows.

Lemma 2: *Regional trade liberalization increases production and consumption in the participating countries but decreases production in the non-participating country. Moreover, consumption in the non-participating country increases if and only if the pollution damage parameter is sufficiently small, i.e. $\beta < \frac{1+3n+3n^2}{3n(1-2\gamma)+6n^2(1-3\gamma)}$.*

The changes in consumption (or sales) in the participating and non-participating countries lead to corresponding changes in the price of the polluting good, and the strength of the rent capture effect, in these countries. The increase in sales in the participating countries implies a decrease in the price of the polluting good in these countries. This weakens the rent capture effect in the non-participating country and tends to raise its pollution tax. If β is sufficiently small, regional trade liberalization also increases sales and decreases price in the non-participating country. This tends

¹⁴Recall that, given our assumption of constant emission intensity of output, the tax on pollution is equivalent to a production tax.

to raise pollution tax in the participating countries through the rent capture effect. On the other hand, if β is large enough to decrease sales and increase price in the non-participating country, the rent capture effect in each participating country is then subject to counteracting forces. For example, country 1's rent capture effect tends to become weaker due to the fall in price in country 2 but stronger due to the rise in price in country 3.

In general, the above-specified changes in consumption and production drive the changes in equilibrium pollution tax and welfare that arise due to regional trade liberalization. For expositional ease, we examine these changes for the two polar cases where pollution is purely local and perfectly transboundary.

4.1 Local pollution

This subsection examines the case of local pollution when $\gamma = 0$. The impact of an equal bilateral reduction in tariff by countries 1 and 2 on equilibrium pollution taxes is then given by

$$\frac{\partial \bar{t}_i(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=0} = \frac{M}{27n(\beta+1)(2n+1)(3n+1)(3\beta+6n\beta+1)}, \quad i = 1, 2 \quad (18)$$

where $M \equiv 3(2n + \beta + 2n\beta)(13n + 9n^2 + 3) - 27n\beta^2(3n + 1)(2n + 1)^2 + 18n + 5$, and

$$\frac{\partial \bar{t}_3(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=0} = \frac{2}{27} \frac{3n\beta(2n+1)(18n+27n^2+2) - (18n+42n^2+27n^3+2)}{n(\beta+1)(2n+1)(3n+1)(3\beta+6n\beta+1)} \quad (19)$$

Proposition 3 follows from the above.

Proposition 3: *When pollution is purely local, regional trade liberalization increases equilibrium pollution tax in the participating (non-participating) country if and only if the pollution damage parameter β is sufficiently large (small).*

PROOF: From (18) we have that M is concave in β , $M|_{\beta=0} > 0$, and $M \leq 0$ if and only if $\beta \geq \beta_A^r \equiv \frac{13n+9n^2+3+\sqrt{138n+835n^2+2466n^3+3537n^4+1944n^5+9}}{18n(2n+1)(3n+1)}$. Moreover, from (19), $\frac{\partial \bar{t}_3(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=0} \leq 0$ if and only if $\beta \leq \beta_B^r \equiv \frac{18n+42n^2+27n^3+2}{3n(2n+1)(18n+27n^2+2)}$.

Proposition 3 indicates that, for pollutants that have very harmful but localized impacts, regional trade liberalization is likely to strengthen environmental protection in participating countries but weaken such protection in non-participating countries.

Regional trade liberalization increases polluting production in the participating countries. Consequently, in these countries, the changing strength of the pollution shifting effect tends to increase the equilibrium pollution tax, whereas the change in the tariff effect tends to decrease it. When pollution is purely local and the pollution shifting effect is at its strongest, Proposition 3 shows that the equilibrium pollution tax in the tariff-reducing countries increases for sufficiently high values of β . On the other hand, in the non-participating country, the tariff effect tends to increase its pollution tax. Moreover, since regional tariff reduction decreases production in the non-participating country, the pollution shifting effect operates in the opposite direction in this country. Hence, pollution tax increases in the non-participating country when β is sufficiently small.

The equilibrium welfare of each country, denoted by $\overline{W}_i(\phi, \Phi)$, can be derived by substituting the equilibrium pollution taxes $\bar{t}_i(\phi, \Phi)$ into (9). The impact of regional trade liberalization on each country's welfare is derived as follows. We first differentiate $\overline{W}_i(\phi, \Phi)$ with respect to ϕ , and then evaluate the resulting expression, which is a function of both ϕ and Φ , at $\Phi = \phi = 0$. This gives the impact of marginal bilateral tariff reduction by countries 1 and 2 on welfare of country i , when evaluated in the neighbourhood of free trade, as follows:

$$\frac{\partial \overline{W}_i(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=0, \Phi=\phi=0} = -\frac{an}{3(3n+1)(\beta+1)} < 0, \quad i = 1, 2 \quad (20)$$

$$\frac{\partial \overline{W}_3(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=0, \Phi=\phi=0} = \frac{2an}{3(3n+1)(\beta+1)} > 0 \quad (21)$$

From (20) and (21), we have Proposition 4.

Proposition 4: *When pollution is purely local, regional trade liberalization in the neighbourhood of free trade increases (decreases) equilibrium welfare in the participating (non-participating) country.*

The changes in welfare in the participating and non-participating countries follow from the changes in production and consumption in these countries brought about by regional trade liberalization. For instance, with local pollution, price of the polluting good exceeds its marginal social cost in the participating countries. Consequently, the increase in consumption and production in these countries increases their welfare.

4.2 Perfectly transboundary pollution

We now take up the case of perfectly transboundary pollution where pollution generated in each country affects all three countries equally (i.e. $\gamma = \frac{1}{3}$). As a result, the pollution shifting effect is absent – this approximates the situation with respect to global pollutants such as greenhouse gases. The impact of an equal bilateral reduction in tariff rate by countries 1 and 2 on equilibrium pollution taxes is now given by

$$\frac{\partial \bar{t}_i(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=\frac{1}{3}} = \frac{36n + \beta + 4n\beta + 78n^2 + 54n^3 + 5}{9n(3n+1)(6n+\beta+3)} > 0, \quad i = 1, 2 \quad (22)$$

$$\frac{\partial \bar{t}_3(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=\frac{1}{3}} = -\frac{2(18n + \beta + 7n\beta + 42n^2 + 27n^3 + 9n^2\beta + 2)}{9n(3n+1)(6n+\beta+3)} < 0 \quad (23)$$

From (22) and (23), Proposition 5 follows.

Proposition 5: *When pollution is perfectly transboundary, regional trade liberalization decreases (increases) equilibrium pollution tax in the participating (non-participating) country.*

When pollution is perfectly transboundary, the increased production in the participating countries does not exert an upward pressure on their pollution tax through the pollution shifting effect. Instead, the reduction in ϕ decreases pollution tax in the participating countries through the tariff and rent capture effects. Converse changes in the tariff and rent capture effects move the pollution tax rate upwards in the non-participating country, as ϕ decreases.

The equilibrium welfare level in each country is derived by substituting the equilibrium pollution taxes $\bar{t}_i(\phi, \Phi)$ into (9). The impact of regional trade liberalization on each country's welfare is obtained as earlier. Thus, we first differentiate $\bar{W}_i(\phi, \Phi)$ with respect to ϕ , and then evaluate the resulting expression, which is a function of both ϕ and Φ , at $\Phi = \phi = 0$. This yields:

$$\frac{\partial \bar{W}_i(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=\frac{1}{3}, \Phi=\phi=0} = \frac{a(\beta(6n + 33n^2 + 54n^3 + 1) - G)}{3(3n+1)(6n+\beta+3)^2}, \quad i = 1, 2 \quad (24)$$

$$\frac{\partial \bar{W}_3(\phi, \Phi)}{\partial \phi} \Big|_{\gamma=\frac{1}{3}, \Phi=\phi=0} = \frac{2a(\beta(48n + 129n^2 + 108n^3 + 5) + G)}{3(3n+1)(6n+\beta+3)^2} > 0 \quad (25)$$

where $G \equiv 9n(2n+1)^2 + \beta^2(7n+9n^2+1)$. The following result holds.

Proposition 6: *When pollution is perfectly transboundary, regional trade liberalization in the neighbourhood of free trade (i) decreases equilibrium welfare in the participating country if and only if the pollution damage parameter takes intermediate values (i.e. $\beta \in (\beta^L, \beta^H)$); and (ii) decreases equilibrium welfare in the non-participating country.*

PROOF: Follows from (24) and (25). Define the numerator of (24), $N \equiv \beta(6n + 33n^2 + 54n^3 + 1) - G$. We have N is concave in β , $N|_{\beta=0} < 0$, and $N \geq 0$ if and only if $0 < \beta^L \leq \beta \leq \beta^H$ where $(\beta^L, \beta^H) \equiv \frac{6n+33n^2+54n^3+1 \pm \sqrt{(108n^3-24n^2-33n+1)(3n+1)^3}}{2(7n+9n^2+1)}$.

The above changes in welfare follow from the relevant changes in production and consumption brought about by regional trade liberalization in the participating and non-participating countries.

5 Comparison

Table 1 summarizes the results for multilateral and regional trade liberalization in the neighbourhood of free trade. The results emerge from the interaction of the rent capture, pollution shifting and tariff effects, and changes in these effects depend on the nature of the trade liberalization process. While multilateral trade liberalization increases production and consumption in all countries, regional trade liberalization reduces production in the non-participating country and may decrease its consumption as well (the latter happens when the pollution damage parameter is sufficiently large). The changes in consumption and production have corresponding impacts on the rent capture and pollution shifting effects in these countries. Moreover, the tariff effect reduces equilibrium pollution tax in all countries in the multilateral case, and in participating countries in the regional case, but increases the non-participating country's tax in the case of regional trade liberalization.

A comparison of the results in Table 1 reveals that multilateral and regional trade liberalization affect pollution tax and welfare in the tariff-reducing countries in similar ways when pollution is local, but in dissimilar ways for perfectly transboundary pollution.

Multilateral trade liberalization increases pollution tax in the participating countries if and only if pollution is sufficiently harmful. A similar result holds for regional trade liberalization when pollution damage is localized. However, for pollutants that have large inter-jurisdictional spillovers (e.g. greenhouse gases), regional trade liberal-

ization always decreases the participating countries' pollution tax. When pollution is transboundary, regional trade liberalization is thus more likely than multilateral trade liberalization to weaken environmental protection in the tariff-reducing countries.

Moreover, when pollution is transboundary, countries undertaking multilateral trade liberalization in the neighbourhood of free trade experience a reduction in welfare. In contrast, regional trade liberalization, in the neighbourhood of free trade, may increase welfare in the participating countries. The difference between multilateral and regional trade liberalization in terms of their impact on welfare of the tariff-reducing countries suggests that multilateralism is likely to be the less preferred option for the establishment of free trade amongst countries. This is in line with the recent experience with respect to multilateral and regional trade agreements discussed in the Introduction.

Further, regional trade liberalization is found to affect pollution tax and welfare in the participating and non-participating countries in very dissimilar ways. When pollution is local but sufficiently harmful, regional trade liberalization strengthens environmental protection in participating countries but weakens such protection in the non-participating country.

6 Conclusion

The paper considers trade between identical countries with imperfectly competitive markets and examines the impact of multilateral and regional tariff reduction on their non-cooperative equilibrium pollution tax and welfare. We find that when production causes pollution, and countries impose a strategic pollution tax that adjusts to changing rates of tariff, trade liberalization may weaken environmental policy and reduce welfare in the tariff-reducing countries.

When a pollution tax is chosen strategically by countries, it is affected by the rent capture, pollution shifting and tariff effects. Tariff reduction changes the magnitude of these effects and is observed to affect equilibrium pollution tax and welfare in ways that depend, in part, on the characteristics of the pollution itself (viz. pollution damage parameter and pollution spillover parameter).

The nature of the trade liberalization process matters as well. While the existing literature has focused on analyzing multilateral trade liberalization, much tariff reduction in the world is undertaken through regional trade agreements amongst a sub-group of trading countries. We find that multilateral and regional trade liberaliza-

tion affects pollution tax and welfare in the tariff-reducing countries in similar ways for local pollution but in dissimilar ways for perfectly transboundary pollution. As well, when pollution is transboundary, regional trade liberalization is more likely than multilateral trade liberalization to weaken environmental protection in the tariff-reducing countries.

In their analysis of trade with perfect competition and non-strategic environmental policy, Copeland and Taylor (2004, p. 29) had noted that, “If pollution externalities are fully internalized, trade must always increase welfare.” However, in our model involving a flexible environmental tax that not only adjusts to changing openness to trade but is also strategically distorted, we find that the distortions can be severe enough to negate the beneficial effects of freer trade. Our welfare results thus provide formal support to what Kennedy (1994, p. 62) had speculated, “However, one can speculate that the strategic distortions associated with openness have the potential to be sufficiently destructive as to more than offset any benefits associated with trade liberalization.”

We have examined the analytically tractable case of identical countries facing linear demand and quadratic pollution cost. Nevertheless, even when these simplifying assumptions are relaxed, production, consumption, and the various strategic effects described above will continue to change differently across countries, leading to differential impacts of multilateral and regional trade liberalization on environmental protection and social welfare.■

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Figure 1: Production, Consumption, and Tariff rates for countries 1, 2 and 3

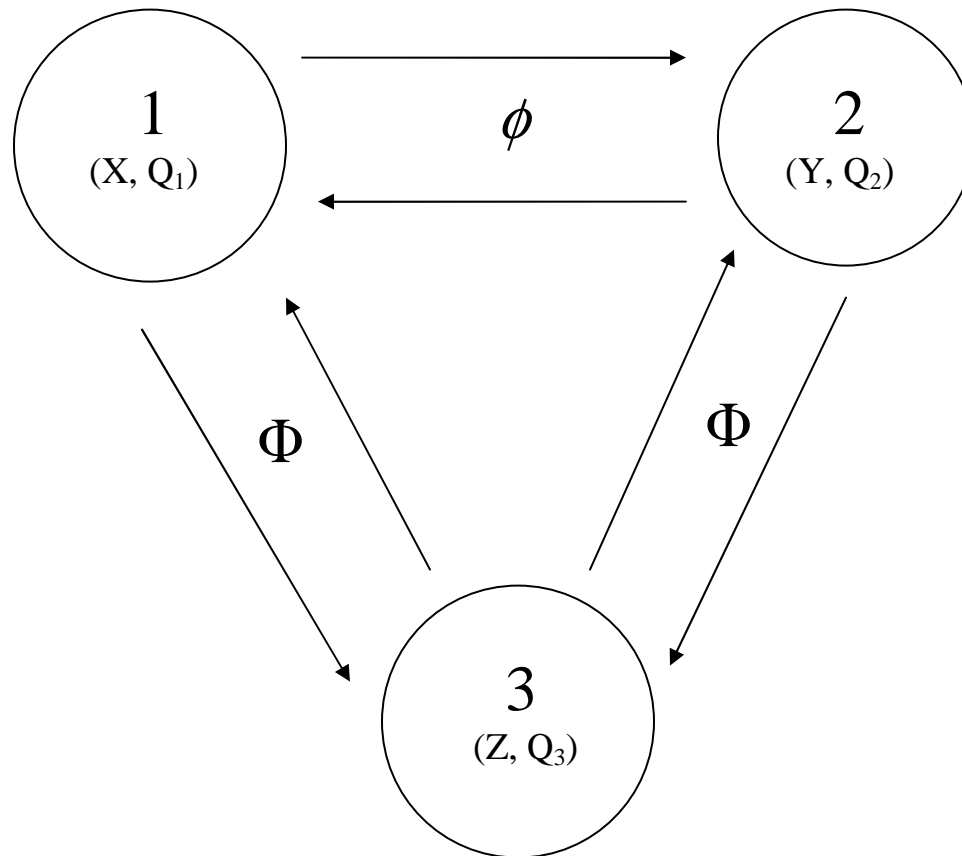


Table 1: Effects of multilateral vs. regional tariff reduction on pollution tax and welfare
(in the neighbourhood of free trade)

	Multilateral Trade Liberalization		Regional Trade Liberalization	
	$\gamma = 0$	$\gamma \in (0, \frac{1}{3}]$	$\gamma = 0$	$\gamma = \frac{1}{3}$
t_1	\uparrow iff β is large	\uparrow iff β is large	\uparrow iff β is large	\downarrow
t_3	\uparrow iff β is large	\uparrow iff β is large	\downarrow iff β is large	\uparrow
W_1	\uparrow	\downarrow	\uparrow	\downarrow iff β is intermediate
W_3	\uparrow	\downarrow	\downarrow	\downarrow